MAGNETIC PROPERTIES OF LITHIUM ORTHOPHOSPHATE CATHODE MATERIALS

Semkin M.A.[1*], Volegov A.S.[1], Sim H.[2], Choi K.-Y.[2], Urusova N.V.[1], Barykina J.A.[1,3], Kellerman D.G.[3], Pirogov A.N.[1,4]

[1)] Ural Federal University, Ekaterinburg, Russia
[2)] Seoul National University, Seoul, Korea
[3)] Institute of Solid State Chemistry of the Ural Branch of the RAS, Ekaterinburg, Russia
[4)] Institute of Metal Physics of the Ural Branch of the RAS, Ekaterinburg, Russia
*E-mail: m.a.semkin@urfu.ru

Annotation. We have studied magnetic properties of cathode materials of the lithium orthophosphate single crystals at low temperatures. Using Curie-Weiss model we determined magnetic constants and analyzed their temperature behavior depend on the type of $3d$ – transition ion. Detected anomaly of susceptibility in near Neel temperature is explained by a magnetic commensurate-incommensurate phase transition.

Materials of a lithium orthophosphate family $LiMPO_4$, where M = Mn, Fe, Co and Ni has been studied as cathode materials for power batteries in electric devices [1, 2]. They possess olivine-type crystallographic structure (space group $Pnma$) and an antiferromagnetic type of magnetic ordering at low temperatures.

The aims of this work are to study the temperature evolution of a magnetic ordering in single crystals of the $LiNiPO_4$, $LiMnPO_4$ and partly (10 %) substituted by Co or Mn, find correlation between magnetic structure and the type of $3d$ – transition ion and explain the nature of very strong interaction between ferroelectric and magnetic subsystems in these materials.

All single crystals have been synthesized by the standard flux growth method. The material of a flux was lithium chloride $LiCl$. Crystallographic axis of the samples were determined by the X-ray Laue back-scattering method, which was realized at an Imaging Plate XRD Laue Camera. Magnetic measurements were carried out with SQUID over temperature range from 2 K up to 300 K in field cold and from 10 K up to 300 K in zero field cold technics and at applied magnetic field 500 Oe along the *a*- and *c*-axes.

Temperature dependences of molar susceptibility show anomaly in narrow temperature region near Neel temperature. To observe this anomaly we measured temperature dependencies with step 0.1 K. We assume the anomaly is originated from a magnetic commensurate-incommensurate phase transition. Curie-Weiss model was applied to analyze the magnetic susceptibility in paramagnetic temperature range and calculation magnetic constants. We obtained constants for $LiNiPO_4$, $LiNi_{0.9}Co_{0.1}PO_4$, $LiNi_{0.9}Mn_{0.1}PO_4$ and $LiMnPO_4$ single crystals. Our data (Neel temperature, magnetic moment of $3d$ – transition metal and Weiss temperature) are presented in Table 1.

Table 1

Magnetic constants in the case of applied magnetic field along the a-axis: T_N is Neel temperature; μ_{eff} is magnetic moment of $3d$–transition metal; θ_p is Weiss temperature.

$3d$–**transition ion(s)**	$T_N\,(K)$	$\mu_{eff}\,(\mu_B)$	$\theta_p\,(K)$
Ni	23	3.53	-78
Ni-Co	24	3.56	-68
Ni-Mn	25	3.60	-81
Mn	37	5.70	-77

Doping lithium nickel orthophosphate by Co- or Mn- ions leads to increase of Neel temperature and the magnetic moment these materials.

The research was supported by the Federal Agency for Scientific Organizations of Russia (theme “Flux” No. 01201463334) and by the State contract (No. 1362) between Ural Federal University and Russian Federation Ministry of Education and Science.

1. Zaghib K., Mauger A., Groult H., Goodenough J.B., and Julien C.M., Materials 6, 1028 (2013).
2. Ben Bechir M., Ben Rhaiem A., and Guidara K., Bull. Mater. Sci. 37, 473 (2014).

ВЛИЯНИЕ ТОЛЩИНЫ ОКСИДНОГО СЛОЯ НА ВОЛЬТАМПЕРНЫЕ ХАРАКТЕРИСТИКИ СТРУКТУРЫ Ti/TiO_2/Au

Дорошева И.Б.*, Грязнов А.О., Камалов Р.В., Вохминцев А.С., Вайнштейн И.А.

Уральский федеральный университет имени первого Президента России Б.Н. Ельцина, г. Екатеринбург, Россия

*E-mail: dorosheva1993@mail.ru

EFFECTS OF OXIDE LAYER THICKNESS ON THE CURRENT-VOLTAGE CHARACTERISTICS OF Ti/ TiO_2/Au STRUCTURE

Dorosheva I.B*, Gryaznov A.O., Kamalov R.V., Vokhmintsev A.S., Weinstein I.A.

Ural Federal University, Yekaterinburg, Russia

Oxide layers with 80, 120, 160 and 200 nm thickness were synthesized on surfaces of titanium foil via electrochemical oxidation for 5, 10, 15 and 20 min, respectively. The current–voltage characteristics of the fabricated Ti/TiO_2/Au sandwich-structure were investigated in full cycles of resistive switching. For micromemristors with ≈ 160 nm oxide thick-